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FETC

F O C U S

On the Road to Future Fuels

U.S. DEPARTMENT OF ENERGY • OFFICE OF FOSSIL ENERGY
FEDERAL ENERGY TECHNOLOGY CENTER

Rita A. Bajura
Director, FETC

Welcome From The Director

Energy forecasters ask, "Where will we find the fuels to satisfy the appetite of a growing, energy hungry world in the coming millennium? What types of fuels will we need to ensure that we protect our environment and satisfy our energy requirements?"

Over the last 40 years, world population has doubled, while energy use has nearly quadrupled. No one can predict what the population growth will be in the next century or what energy trends will dominate. However, we can recognize that sufficient quantities of environmentally benign and cost-effective fuels will be needed to support a growing world population and growing economic aspirations.

FETC has taken on the research and development challenge to produce these fuels. We are working with our stakeholders to secure the most effective methods for accessing and using our fossil fuel resources—coal, petroleum, and natural gas. We are also looking at future fuels to reduce emissions and to maximize the use of our resource base.

The search for alternative fuel sources began in the 1930s. Research advances are making these alternative fuels more cost effective today. FETC's future transportation fuels initiatives include developing zero-sulfur fuels—Fischer-Tropsch diesel, methanol, and dimethyl ether—to further reduce emissions. Compressed natural gas or hydrogen for powering vehicles are other alternatives.

Highly efficient diesel engines or fuel-cell-powered vehicles could dominate the future vehicle market. FETC is on the forefront of providing advanced, clean fuels for these advanced technologies. We are providing the research and technological innovations necessary to move new fuels to the commercial market in the new millennium.

Our fuels programs have one common goal: to ensure that the U.S. has environmentally sound and cost-effective options for its transportation and other energy sectors. Because fossil fuels will continue to be used for the foreseeable future, even in a carbon-constrained environment, we are working on technologies that will dramatically improve the environmental performance of fossil fuels.

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Family vehicles in the U.S. consume enough fuel each year to cover a regulation-size football field to a depth of about 40 miles. FETC partners with industry and other organizations to develop and deploy ultra-clean, high-performance fuels, ensuring that we can continue to depend on our transportation-based economy to bolster our transportation-based lifestyle.

Frederick R. Brown
Associate Director

Office of Product Management for Fuels and Speciality Markets

On the Road to Future Fuels

Literature is fuel for the mind. Music is fuel for the soul. Wood is fuel for the fireplace, and gasoline is fuel for the car. Whether we consider fuel in a literary or technical sense, we need fuel. FETC's research is fuel for the future—helping the U.S. travel the road to a future powered by cleaner fuels.

The comforting sounds of fossil fuels at work: the whoosh of a gas furnace on a cold winter morning, the hum of an air conditioner on a hot summer day, the purr of a smooth-running automobile, the roar of a jet passing overhead.

We depend on fossil fuels. But burning them causes problems. As early as 1775, fossil fuel use was recognized as causing cancer among chimneysweeps in London. The killer smogs in Brussels (1930); Donora, Pennsylvania (1948); and London (1952) were a clear call to action. In 1946, Allegheny County, Pennsylvania, passed a smoke control ordinance—transforming the Pittsburgh area from from the "Smoky City" where headlights were needed at noon into the Golden Triangle.

The first national action was the Clean Air Act of 1970, establishing the first specific responsibilities for government and private industry to reduce emissions from vehicles, factories, and other pollution sources. The result? Today's cars typically emit 70 to 90 percent less pollution over their lifetimes than their 1970

counterparts. Emissions of sulfur dioxide and nitrogen oxides from the nations power plants have been reduced by millions of tons per year. Many cities have the cleanest air in decades.

So why are we still experiencing smog and related health problems? Atlanta, Georgia, for example was blanketed with "unhealthy" air this summer for 35 of 36 consecutive days. In fact, unhealthy air pollution levels still plague virtually every major city in the U.S. Why? Development and urban sprawl have created new pollution sources. Vehicle traffic has doubled since 1970. And we now recognize environmental threats such as air toxics. In the past decade, the potential for unrestrained use of fossil fuels to alter Earth's climate has become a major issue.

To deal with the potential of climate change, we must use fossil fuels in the most efficient manner possible. To provide clean, healthy air to all Americans, pollution from burning fossil fuels will have to be further reduced. Futhermore, the efficient and clean use of fossil fuels must be an integrated effort.

For example, U.S. car manufactureres are developing autos capable of 55-80 miles per gallon using high-efficiency diesel and diesel-electric hybrid power trains. But these power trains can't meet proposed Environmental Protection Agency regulations using current generation petroleum fuels. FETC is actively developing cleaner fuels that can be used with these engines to meet future regulations.

Greg Kawalkin, Senior Advisor, Fuels & Specialty Markets, discusses DOE's new clean fuels initiative at a public meeting held in Cincinnati, Ohio.

FETC is committed to making sure that we have enough clean, affordable fuel to maintain our lifestyles in a healthful environment, now and in the future. Our fuels programs focus on clean fuels—fuels that can power the 21st century and beyond in an environmentally conscientious age.

Expanding Our Natural Gas Supply

A major FETC research priority is in natural gas supply and storage: expanding our natural gas resource base and processing natural gas for use in new markets.

U.S. demand for natural gas is expected to rise to 30 to 35 trillion cubic feet (Tcf) by 2020, nearly 50 percent higher than the 1997 level of 22 Tcf. Natural gas will fill more and more of the energy needs of our utility and industrial sectors—as demand for electricity increases and as nuclear power plants are retired. Also, the restructuring of the electricity industry is currently favoring construction of less capital-intensive and more efficient natural-gas generation technologies.

To supply this increased demand, we need to locate and define additional reserves of gas, develop technologies to recover a greater portion of the gas in each reservoir, and reduce the cost of producing gas from currently uneconomical formations. FETC actively promotes natural gas exploration and production strategies to reduce the risks and uncertainty in developing new reserves and to reduce the costs associated with recovery.

FETC's Gas Supply Program Strategy

- ☑ ***Ensure*** the reliability of the future gas supply by reducing drilling costs, improving the success rate in finding gas, and increasing recovery efficiency.
- ☑ ***Develop*** adequate storage capacity to meet expected needs by solving problems with existing fields and advancing designs for on-site storage.
- ☑ ***Process*** natural gas for selected markets such as transportation fuels, including the upgrading of low-quality gas and converting natural gas to liquid fuels.

Unconventional Gas Recovery. Only a small number of high-quality conventional natural gas reservoirs remain undeveloped in the lower 48 states. Assuming no discoveries are made of major new conventional resources, the U.S. will depend on gas that comes from unconventional sources: where the gas is located with coal (as coalbed methane) or in rock formations that: have complex geology and are deep (15,000 feet or more below the surface), hard to drill (abrasive to drill bits), or relatively impermeable ("tight" formations where gas flow is constrained). The challenge is to make these resources economic through research and development of advanced gas exploration and extraction technologies.

Stranded Gas. The reservoirs of natural gas beneath Alaska's North Slope are part of a huge supply of natural gas that is currently unmarketable. FETC is looking at ways to use the Fischer-Tropsch process—which can be used to convert natural gas into a liquid fuel—to make this remote gas accessible. If the gas were converted to a liquid, it could be transported via the Trans-Alaska Pipeline system. As an added benefit and impetus to researching this possibility, a commercially viable gas-to-liquids industry on the North Slope could extend the life of the Trans-Alaska Pipeline system by 20 years or more.

New Sources. While proven worldwide natural gas reserves in conventional reservoirs are in the thousands of Tcf, the methane hydrates resource may contain *hundreds of millions* of Tcf. The U.S. Geological Survey has estimated the U.S. gas hydrates resource to be 320,000 Tcf, with major deposits located off the Carolina coasts, off the coasts of California and Oregon, in the deep-water portions of the Gulf of Mexico, and beneath the permafrost in Alaska. Compare this forecast to the total estimated U.S. natural gas resource, excluding hydrates, of about 1,500 Tcf! If safe production of methane from hydrates becomes technically feasible and economically viable, long-term energy security will be ensured.

DOE is establishing a new 10-year comprehensive interagency program to identify and characterize this potential major natural gas source, and FETC will coordinate the research efforts.

Gas Storage. We have an efficient natural gas pipeline and transmission system—gas flows primarily from the producing areas in Texas, Louisiana, and offshore areas of the Gulf of Mexico towards the northeast and midwest. In addition, producers store natural gas in underground fields (such as mined-out cavities or depleted wells) during summer months to meet higher demands during winter months.

But the U.S. is going to need additional transmission and storage capabilities to meet the expected increase in demand for natural gas. FETC promotes the development of advanced technologies and methods to enhance and expand the natural gas delivery and storage system. The dual focus is on (1) applying stimulation technology in gas storage fields to increase gas deliverability, and (2) engineering designs for advanced storage concepts to meet peak demand on-site at power generation sources.

The [automobile] industry today is on the verge of major technical innovations that might be as far-reaching as the switch from horses to horsepower.
Don Walkowicz, executive director of the U.S. Council for Automotive Research (USCAR).

FETC's Transportation Fuels and Chemicals Program

- ☑ ***Develop*** advanced technologies to produce synthesis gas from natural gas, coal, and other fossil-based carbons such as petroleum coke and refinery wastes.
- ☑ ***Convert*** this synthesis gas to ultra-clean, sulfur-free diesel fuels, fuel-blend liquids, and fuel additives.
- ☑ ***Develop*** longer-range technology to convert methanol, methane, and other hydrocarbons to advanced transportation fuels and chemicals.

Transportation: Key to the American Lifestyle

We want to be able to live in comfort anywhere—from a mountain-top retreat to the heart of a major city. We want the freedom to go wherever we want, whenever we want, and to live and work anywhere—often not near the sources of goods and services we also want and need. These expectations require transportation.

We also expect our vehicles to be high performance and comfortable. Even in today's environmentally conscientious age, we will not give up our automobiles—but we do expect them to become non-polluting. That's a tall order! Vehicles currently account for approximately 80 percent of the carbon monoxide, 50 percent of nitrogen oxides, 40 percent of volatile organic compounds, and 35 percent of the carbon dioxide emitted into our air.

One answer is to construct better vehicles—higher mileage, near-zero emissions—without sacrificing affordability, comfort, safety, and power (or we won't buy them). The automotive industry is working on this answer. The United States Council for Automotive Research (USCAR)—an alliance of DaimlerChrysler, Ford, and General Motors—was formed in 1992 to strengthen the technology base of the domestic auto industry through cooperative, pre-competitive research.

But improving the vehicles is only a part of the answer. Vehicle emissions are directly traceable to the fuels used. One of FETC's major research areas is transportation fuels. We partner with domestic transportation and fuels industries and research and development organizations. Our goal is to develop and promote advanced, economic, alternative transportation fuels to reduce the emissions from increasingly efficient engines.

This complex balancing act in transportation fuel development—cost effectiveness, efficiency, environmental friendliness—requires the participation of all stakeholders, including government and industry. FETC is performing its strategic role of bringing together parties who can most effectively solve the challenges of future transportation needs. This collaboration aids the transportation industry in meeting emissions standards. It also strengthens the economy through new and better uses of domestic fossil fuel resources and the resulting new industries.

Gas-to-Liquids Technology. Advanced transportation fuels can be produced using the Fischer-Tropsch (F-T) process, a decades-old process that converts gas made from coal, natural gas, or biomass into petroleum-like fuels and chemicals. The standard process successfully produces synthetic fuels, but the liquid products are costly compared to relatively inexpensive conventional petroleum. FETC's F-T research is designed to produce a clean-burning diesel fuel that can meet projected clean-air emission standards. This fuel is compatible with current and future engines, and it can be blended with low-quality petroleum-derived diesel fuel. Production of F-T diesel fuel from domestic fossil energy resources can also reduce U.S. dependence on foreign sources of oil.

Conversion to Methanol. An innovative, cost effective, environmentally friendly method for producing liquid fuels and chemical feedstocks from coal-derived synthesis gas is being demonstrated at Eastman Chemical Company's coal gasification facility in Tennessee. The DOE-industry cooperative project uses

the liquid-phase methanol (LPMeOH™) process at the facility. FETC hopes to use the facility to demonstrate another new fuel—dimethyl ether, or DME—a zero-sulfur fuel that also can be used as a diesel fuel supplement.

Fuel for Living—Powering a Clean 21st Century

FETC has joined with the DOE Office of Energy Efficiency and Renewable Energy, and the Office of Fossil Energy, to conduct research on using hydrogen as a fuel. Hydrogen is abundant—representing about three-fourths of all matter. Hydrogen is clean—a zero-emissions fuel. The goal is to make the fuel cheaper to produce, and to build the necessary infrastructure to make it accessible.

Hydrogen can be used to fuel a fuel cell. Continuing developments in fuel cells show promise for their application in distributed power generation systems in industrial and commercial facilities as well as for powering cars and other vehicles. Fuel cells are poised to move into widespread use. The challenge remains to reduce their cost and to build a manufacturing and service infrastructure.

Our fuels research also includes an international focus. FETC facilitates the adoption of clean, safe, and efficient energy systems in developing countries. Recent collaboration with community leaders, an engineering firm, and South African government organizations is an example. This collaboration included discussion of the needs for improved heating, low-smoke fuels, energy-efficient housing, and improved power generation and distribution. The result has been much cleaner air and healthier citizens—and an energy-efficient demonstration house that has served as a model for hundreds of attractive, better-designed houses in a rural township in the Republic of South Africa.

Choices for a New Century

Without continuing research and development in alternative fuels, we face a future of dwindling resources, higher prices, and greater dependence on imported fuel. FETC programs are continuing to provide more options. Our fuels programs and projects are highlighted in this issue of *FETC Focus*.

From compressed natural gas to hydrogen-powered fuel cells to high-efficiency diesel and multi-fuel engines, Americans will be able to fuel their appetites for travel. We've come a long way in our transportation history from the first gas guzzlers puttering down a country road to alternative fuel vehicles now commuting along Interstate 79 every day in Pennsylvania and West Virginia, stopping to refuel with clean compressed natural gas. We have even farther to go.

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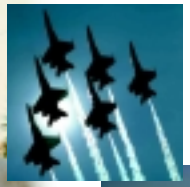
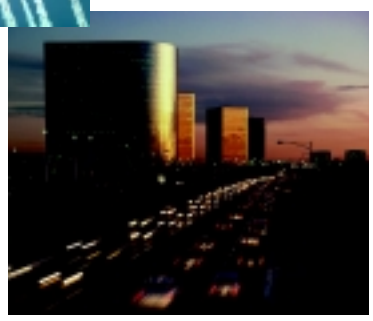




Hydrates—The Final Natural Gas Frontier

A frontier is the outer limit of knowledge, the boundary beyond which the opportunities for research and development have not been exploited. Gas hydrates truly are a frontier in natural gas exploration, and FETC is committed to exploring the options for unlocking the gas hydrates puzzle.

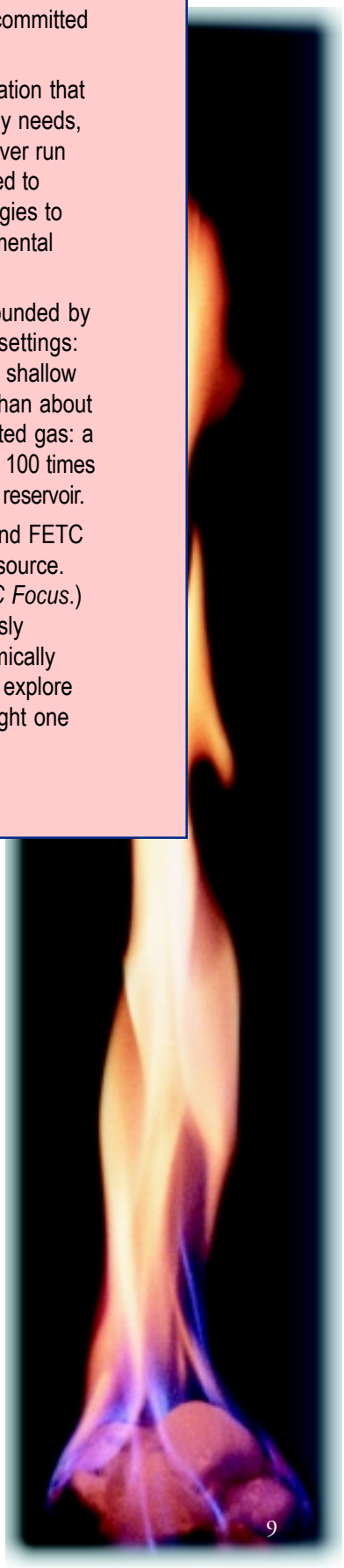
DOE, and particularly FETC, can be credited with the growing realization that the hydrates resource could be the answer to the world's fossil energy needs, that the potential resource is so vast and so rich that the world will never run out of natural gas. However, to make hydrates a viable option, we need to determine the true size and nature of the resource, develop technologies to economically and safely extract the gas, and determine the environmental impacts, if any, of such actions.

Methane hydrates are crystalline solids—each gas molecule is surrounded by a cage of water molecules. Hydrates form in two types of geologic settings: (1) on land in permafrost regions where cold temperatures persist in shallow sediments, and (2) beneath the ocean floor at water depths greater than about 500 meters where high pressures dominate. Hydrates are concentrated gas: a cubic foot of hydrates can hold up to 170 cubic feet of gas—from 40 to 100 times as much methane as a cubic foot of reservoir rock in a conventional gas reservoir.

DOE funded a gas hydrates research program from 1982 to 1992, and FETC was a key player, performing some of the earliest research on the resource. (See "Hydrates: Fire From Ice" in the September 1998 issue of *FETC Focus*.) With no immediate economic payoff, the private sector is not vigorously pursuing research that could make hydrates technically and economically viable. Therefore, federal investment is the primary way the U.S. can explore the viability of a high-risk resource whose long-range possibilities might one day dramatically change the world's energy portfolio.

The President's Committee of Advisors in Science and Technology (PCAST) recommended in 1997 that DOE develop a science-based program with industry and other government agencies to "…understand the potential of methane hydrates worldwide." A second round of DOE funding is scheduled for another 10-year program beginning in 2000; FETC will again be a key player. The program will build upon the existing knowledge base, and FETC will coordinate, integrate, and synthesize the research efforts necessary to:

- ☑ ***Establish*** estimates of the U.S. and global methane hydrates resources.
- ☑ ***Develop*** the technology to commercially produce methane from hydrates.
- ☑ ***Understand*** and ***quantify*** the role of methane hydrates in the global carbon cycle and the relationship to global climate change.
- ☑ ***Assess*** concerns on safety and sea-floor stability issues and other engineering problems attributed to methane hydrates.



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U.S. Department of Energy
Office of Fossil Energy

Printed in the United States on recycled paper

Fall 1999